

Cardiac Output Module, M-COP (Rev. 02)
Cardiac Output and SvO₂ Module, M-COPSv (Rev. 00)

All specifications subject to change without notice

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INTRODUCTION

Datex AS/3 Cardiac Output Modules, M-COP and M-COPSv are single width plug-in modules for use with the Anaesthesia and Compact Monitors. Both modules provide cardiac output (C.O.), right ventricular ejection fraction (REF) and invasive pressure measurement. Additionally the COPSv module provides venous oxygen saturation (SvO₂) measurement.

NOTE: Do not use identical modules in the same monitoring system. The COP and COPSv modules are considered as identical modules.

I SPECIFICATIONS

I.1 General Specifications

Module size (W x D x H)	37 x 180 x 112 mm 1.5 x 7.1 x 4.4 in
Module weight	0.35 kg / 0.8 lbs
Power consumption, M-COP	About 3.5 W
Power consumption, M-COPSv	About 5 W

I.2 Typical Performance

C.O.

Measurement range	0.1 to 20 l/min
Display resolution	0.01 l/min
Repeatability	> ± 2 % or ± 0.02 l/min (measured from electrically generated flow curves)
Max. change in blood temp	2.99°C
Injectate temp range (with Edward's compatible probes)	0 to 25.5°C $\pm 0.3^\circ\text{C}$ 25.5 to 27.0°C $\pm 0.5^\circ\text{C}$
Blood temp range (with Edward's compatible catheters)	17.5 to 30.9°C $\pm 0.5^\circ\text{C}$ 31.0 to 43.0°C $\pm 0.3^\circ\text{C}$
Protection against electric shock	type CF defibrillation proof
REF	
Repeatability (Measuring range 10-60 %)	± 2 %

SvO₂

Accuracy $\pm 2 \%$
(Measuring range 30-95 %)
Equals to standard deviation when using in vivo calibration

InvBP

Measurement range -40 to 320 mmHg
Zero adjustment range ± 150 mmHg
Calibration range $\pm 20 \%$

Scales Upper limit is adjustable
between 10 and 300 mmHg
in steps of 10. Lower limit
is 10 % of selected upper
limit below zero.

Sweep speed 12.5, 25, 50 mm/s

DIGITAL DISPLAY:

Range -40 to 320 mmHg
Resolution ± 1 mmHg

WAVEFORM DISPLAY:

Range -30 to 300 mmHg

PULSE RATE:

Measurement range 30 to 250 bpm
Resolution 1 bpm
Accuracy ± 5 bpm
Respiration artefact rejection

1.3 Technical Specifications

Digital display averaged over 5 seconds and updated at 5 seconds intervals.

Error	$\pm 5\%$ or ± 2 mmHg
Transducer and input sensitivity	5 $\mu\text{V/V/mmHg}$, 5 VDC 20 mA max current
Input resistance	$10^{10} \Omega$
Zero drift	<0.1 mmHg/ $^{\circ}\text{C}$
Nonlinearity	$<1\%$, 0 to 200 mmHg $<2\%$, -40 to 0 and 200 to 320 mmHg
Gain drift	$<0.05\%$ f.s./ $^{\circ}\text{C}$
Filter	0 to 20 Hz(-3 dB)
Zero set accuracy	± 1 mmHg
Calibration resolution	± 1 mmHg
Zero time	less than 5 sec

Protection against electric shock type CF defibrillation proof

NOTE: The accuracy of the measurement may be different from the specified accuracy, depending on the transducer/probe used. Please check the transducer/probe specification.

2 FUNCTIONAL DESCRIPTION

2.1 Measurement Principle

Cardiac Output and REF

Cardiac output measurement is made by principle of thermodilution. In measurement the catheter lies in the heart with an injection port in the right atrium (RA) and a thermistor, which is to monitor blood temperature, in the pulmonary artery (PA). A small, known amount of thermal indicator is injected into the RA and is mixed with the blood on its way to the PA. The catheter thermistor measures the decrease in blood temperature as the blood flows past the thermistor in the PA.

The information is stored in the module and cardiac output is calculated from the area beneath the thermal curve.

The area under the time-temperature curve is inversely proportional to the flow rate which corresponds to cardiac output.

Cardiac output is calculated from the equation:

$$C.O. = \frac{1.08 C_T 60 V_i (T_B - T_i)}{T_B dt + C}$$

where:

C.O.= cardiac output in liters/minute

1.08 = factor comparing density and specific heat of 5% dextrose solution in water to ones of blood.

C_T = correction factor for the injectate temperature rise as it passes through the catheter and its dead space

60 = seconds/minute

V_i = injectate volume in liters

T_B = baseline blood temperature ($^{\circ}\text{C}$)

T_i = injectate temperature

$T_B dt$ = area under thermodilution curve between time 0 and x , where x is the time when the curve has dropped to 30% of its peak value.

C = area beneath thermodilution curve between x and end of the curve.

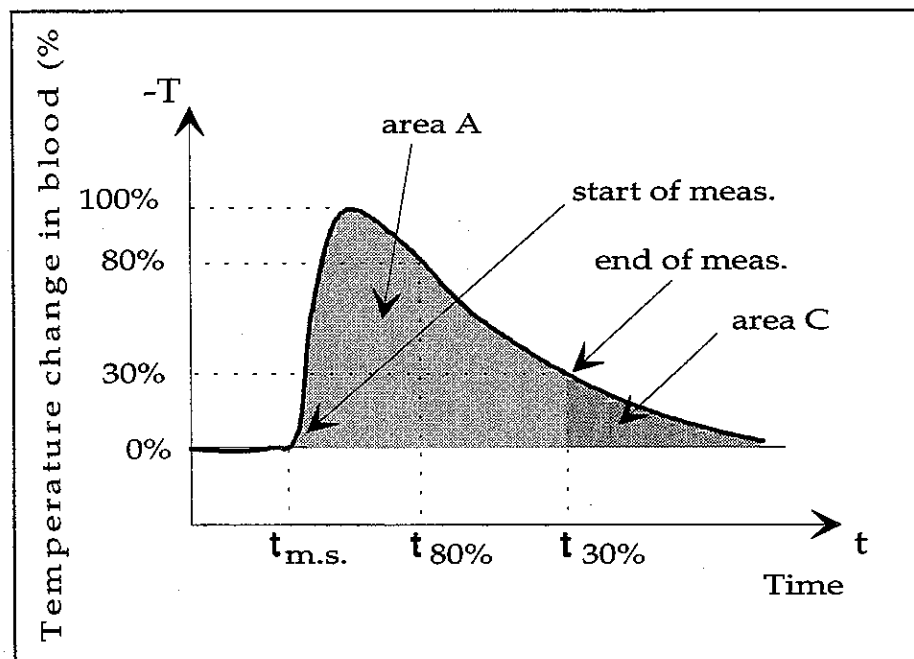


Figure 1 Cardiac Output Measurement Curve

A = area derived by integration of the time temperature thermodilution curve

C = area beneath the thermodilution curve between $t_{30\%}$ and end of the curve. Computation based upon an exponential fit to the curve between $t_{80\%}$ of the peak and $t_{30\%}$.

REF (right ventricular ejection fraction) measurement is a part of the thermodilution cardiac output measurement. Ejection fraction is determined using an exponential technique by synchronizing sensed R-waves with points of temperature changes on the thermodilution curve. Once ejection fraction, cardiac output, and heart rate are known, right ventricular volumes may be calculated. The measurement requires BAXTER Edwards fast response thermistor catheter and also ECG-module to synchronise R-wave detection to the thermodilution curves.

SvO₂ Measurement (COPSv module only)

The COPSv module measures SvO₂ when coupled with Baxter-Edwards OM-2E optical module and Swan-Ganz oximetry catheter. To measure SvO₂, the system utilizes a spectrophotometric technique involving the use of light-emitting diodes (LEDs) that produce red (660 nm) and infrared (810 nm) light. The light is transmitted to the blood through a single plastic optical fiber in the oximetry catheter and reflected back through a separate optical fiber to a photodetector in the optical module. The light is electrically transmitted to the COPSv module and analyzed to determine SvO₂.

The oximetry portion of the system measures SvO₂ in the pulmonary artery by detecting colour changes in the red blood cells. When pulses of red and infrared light are transmitted through the oximetry catheter, the light is reflected from the red blood cells and transmitted back through the catheter to the optical module. The amount of light reflected at each wavelength depends primarily on the colour of the blood and the number of red blood cells. Since the number of red blood cells in the blood affects the amount of reflected light, the differences are compensated when the patient's total haemoglobin value is entered. The optical module stores and transfers SvO₂ calibration data. SvO₂ values can be affected by the presence of methemoglobin or carboxyhaemoglobin which imitate the absorption characteristics of HbO₂. Large concentrations of methemoglobin or carboxyhaemoglobin could then cause a falsely elevated SvO₂. In cases where dysfunctional

haemoglobins are suspected, SvO_2 should be interpreted with caution.

Invasive Blood Pressure Measurement

To measure invasive blood pressure, a catheter is inserted into an artery or vein. The invasive pressure setup, consisting of connecting tubing, pressure transducer, an intravenous bag of normal saline all connected together by stopcocks, is attached to the catheter. The transducer is placed level with the heart, and electrically zeroed.

The transducer is a piezo-resistive device that converts the pressure signal to a voltage. The monitor interprets the voltage signal so that pressure data and pressure waveforms can be displayed.

2.2 Main Components and Block Diagram

The COP module consist of the COP board and two input boards, the CO input board and the P input board, attached to the front panel. (The front panel components are shown in figure 2.)

The COPSv module consist of the COPSv board and three input boards, the CO input board, the SvO₂ input board and the P input board, attached to the front panel. The front panel components are shown in figure 2.

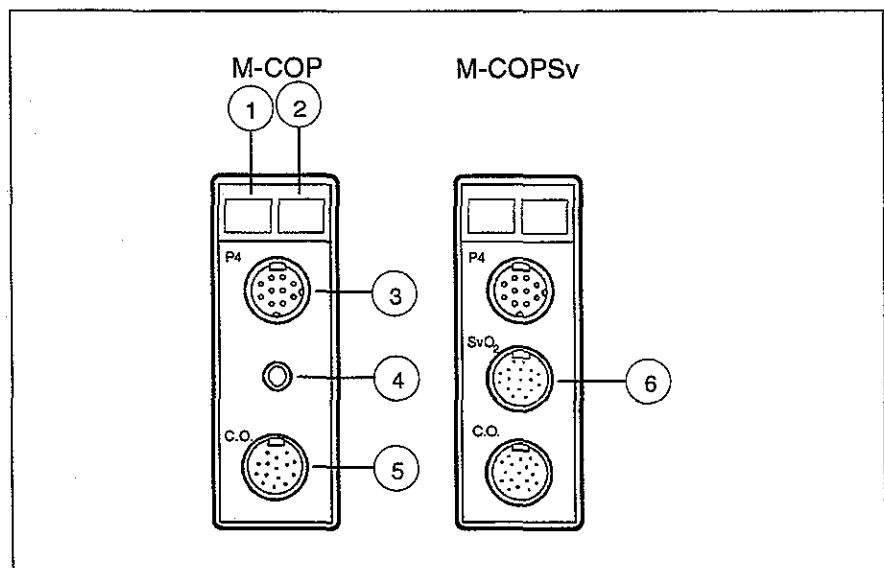


Figure 2 Front Panel Components

- (1) Key for pressure zeroing (zero P4)
- (2) Key for cardiac output measurement (Start C.O.)
- (3) Connector for invasive pressure measurement (P4)
- (4) Connector for C.O. self test
- (5) Connector for C.O. measurement (C.O.)
- (6) Connector for SvO₂ measurement (SvO₂)

2.2.1 COP Board

The COP board consists of the following functional sections.

- Processor section
- Cardiac output measurement section
- Cardiac output self test
- Invasive BP measurement section
- Serial communication
- Isolated section
- Power supply section

Processor section

As the processor, Intel's 80C196KC-16 is used. There are external memories, an 8-bit data bus, a 16 MHz oscillator, and a watchdog timer. Three A/D-converters within the processor are used. The processor's internal UART communicates with the host monitor.

Cardiac output measurement section

The catheter and the probe contain NTC-resistor that reacts to temperature change.

Temperature dependent voltage over the NTC-resistor is amplified and offset value is added to it, then regulated into ± 5 V range in voltage slicing and sent to A/D converter.

Because the temperature measurements are calibrated digitally and non-linearity of catheter/probe is compensated by software, ambient temperature change after calibration is the only factor that may have influence upon the measurement.

Cardiac output self test

There is a connector for C.O. test on the module front panel to find out whether the fault is in the catheter or in the module.

When the cable is connected to the self-test connector, processor starts the test program automatically. First, the processor measures 30°C. Then, it activates test circuits and measures 37°C and then 41°C.

If the measured values are correct ('Cable OK' message is displayed) the fault is in the catheter, and if not correct ('Cable fault' is displayed), the fault is either in the module or in the catheter connecting cable.

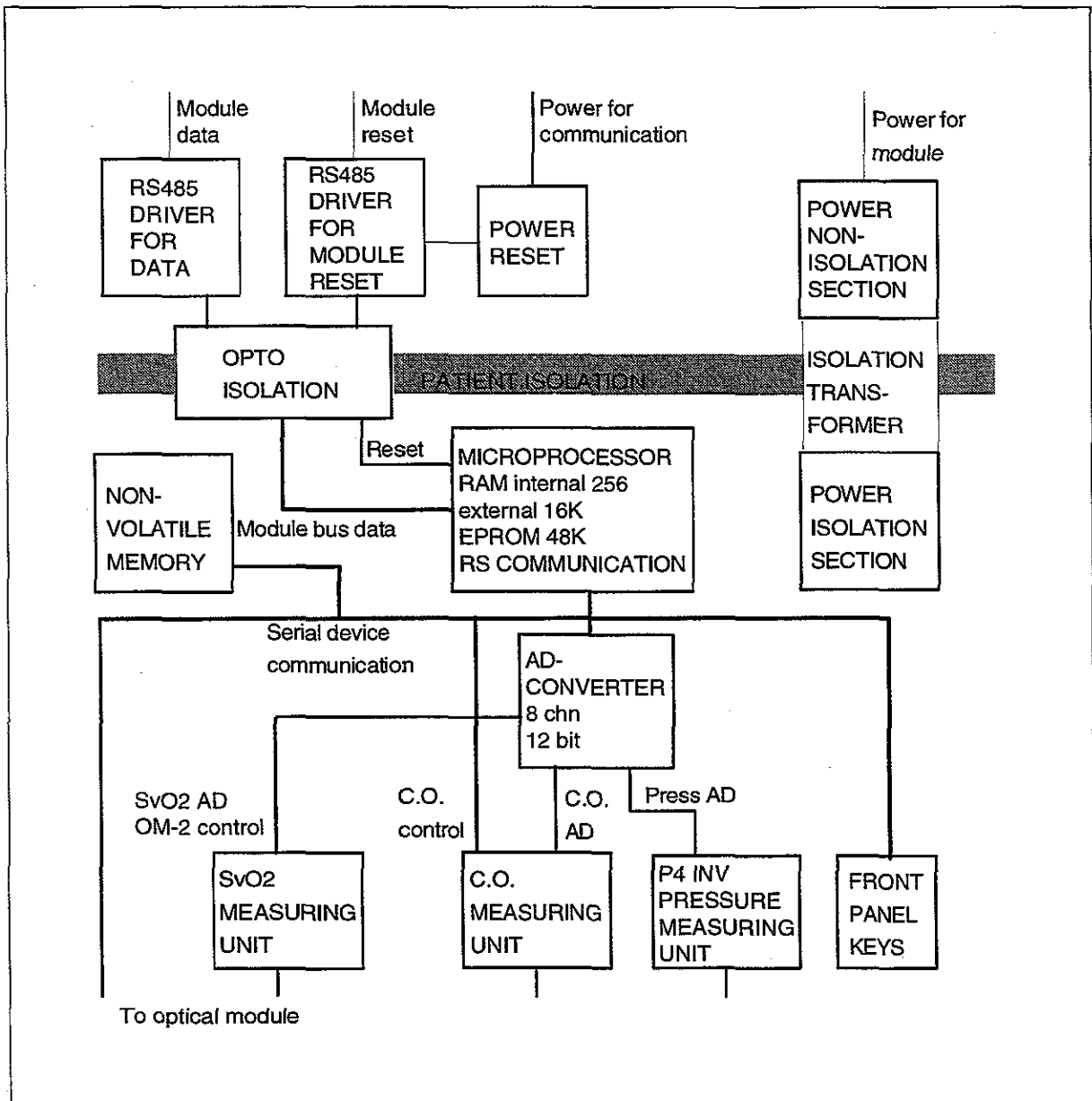


Figure 3

COPsv Board Block Diagram, in COP Board
the SvO₂ Section is Excluded

Invasive BP measurement section

Isolated +5 V voltage is supplied to the pressure transducer. From the bridge connection a differential voltage, which depends on pressure and supplied voltage, is calculated (see the formula below).

$$U_{out} = U_{in} \times \text{Pressure} \times 5 \text{ V}$$

where $U_{in} = 5 \text{ V}$

$$U_{out} = 25 \text{ V} \times \text{Pressure [mmHg]}$$

Pressure amplification is realized in the instrumentation amplifier. Gain of the amplifier is set so that the level of the signal transferred to A/D converter stays within the measurement range even when there are circumstantial offsets or offsets caused by the transducer. There is a filter before the amplifier to attenuate high frequency disturbances.

There is also FET switch, which, by cutting the measurement current, detects the existence of the transducer. The existence of the transducer is also checked binary by the jumper beside the connector.

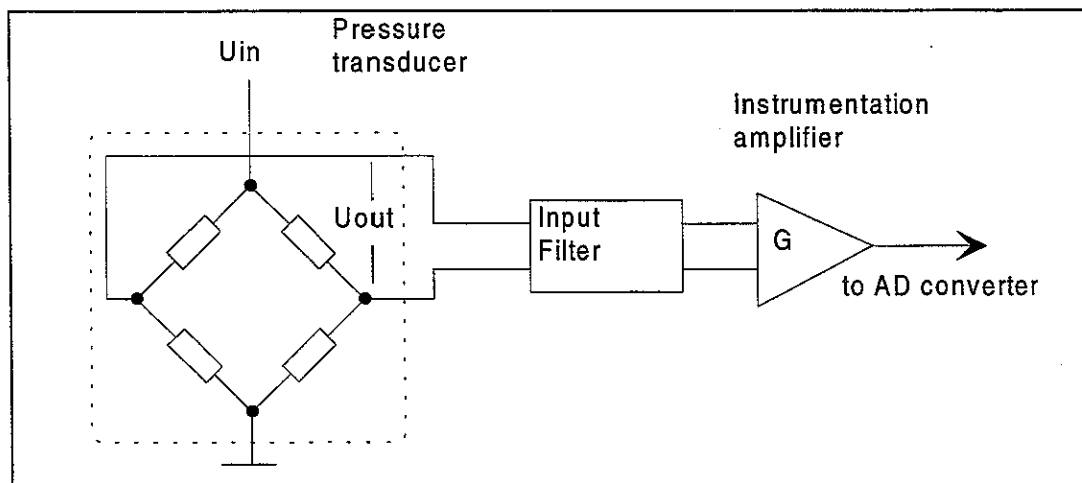


Figure 4 Pressure Transducer Working Principle

Serial communication

Serial communication between the module and the frame is done by RS485 type bus whose buffers get their supply voltage (+5 VDC) from the Central Unit and in the isolation section get the supply voltage (+5 V) from the isolated power supply.

The buffers of the serial communication are controlled also by Reset-signal, when the Reset is active, the buffer does not transfer data.

Reset is also RS485 type and additionally, there is an auxiliary logic power reset, which keeps the reset active for about 500 ms despite the state of reset in the module bus. Time constant determines the power-up reset time. There are components to prevent the module from sending data during reset.

Data transmission rate is 500 kbit/s.

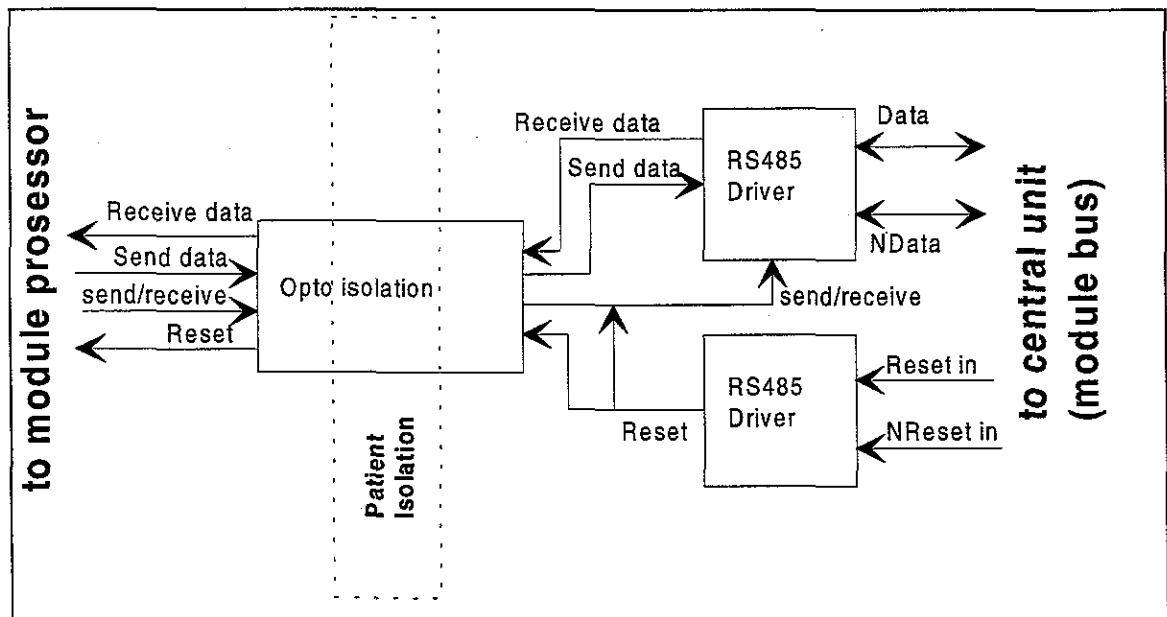


Figure 5 Serial Communication and Opto Isolation

Isolated section

Signal is processed on logical high-low level even though the output of the opto isolators is analog signal in the isolated section.

Reset line is an open collector type with a pull-up resistor. Thus the processor is able to use its internal watch-dog function.

Power supply section

Isolated supply voltage of the module is developed from +15 Vdirty voltage from the host monitor.

Power supply is a switched-mode circuit, where a FET transistor switch is controlled by an oscillator using bipolar timer. Controlling of the FET switch is slowed to suppress spurious interference. A special pulse transformer is used in the circuit. In the secondary circuit normal linear regulators are used except for +5 V (low drop type linear regulator).

2.2.2 COPSv Board

The COPSv board consists of the same functional sections as the COP board, except for the cardiac output self test section. Additionally the COPSv board consists of the SvO₂ measurement section.

SvO₂ Measurement Section

The SvO₂ algorithm is a part of the COPSv module software. The algorithm consists of five different parts; initialization, calibrations, signal processing and SvO₂ calculation, automatic gain control, and signal quality analysis.

Initialization

When the optical module is connected to the COPSv module, a number of start-up procedures are performed prior to normal operation. These procedures include transfer of calibration factors from the optical module to the COPSv module and initialization of LED currents.

Calibration

The system is calibrated according to either in-vitro or in-vivo calibration. In-vitro calibration is performed before the oximetry catheter is removed from the package with the catheter tip still inside the calibration cup. The resulting calibration factor is calculated on the basis of the measured ratio of red and infrared signals and the ideal ratio for the calibration cup. In-vivo calibration is performed when the catheter is inserted into the patient's pulmonary artery. The resulting calibration factor is based on the measured ratio of red and infrared signal and the Hgb and SvO₂ values measured in a laboratory. If the calibration is skipped, the result of an old calibration is used instead and "Not calibrated"-message is displayed in the SvO₂ number field.

Signal Processing and SvO₂ Calculation

The reflected red and infrared signals transferred from the optical module to the COPSv module are filtered, and SvO₂ is calculated on the basis of the ratio of the signals.

Automatic Gain Control

The intensity of the red and infrared signals can be amplified by four different gains. The gain is selected automatically to achieve optimal signal levels.

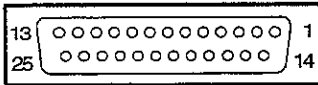
Signal Quality

The reflected red and infrared signals are checked for wall contact artefacts, pulsatility and intensity shifts. An index is calculated to indicate the signal quality. 0 indicates a normal signal, 1 indicates an intermediate signal, 2 indicates a poor signal, and 3 indicates an unacceptable signal. Please refer to the service menu section for more information.

2.3 Connectors and signals

2.3.1 Module Bus Connector Configuration

Rear panel 25-pin female D-connector (X1)

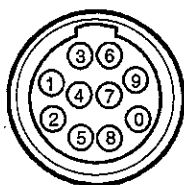


Pin	I/O	Signal
1	I	RESET_RS485*
2	I	-15 VDC*
3	I	+15 VDIRTY*
4	I	+15 VDC*
5	I/O	-DATA_RS485*
6	I/O	DATA_RS485*
7	-	Ground & Shield*
8	I	-RESET_RS485*
9	I	CTSB
10	O	RTSB
11	I	RXDB
12	O	TXDB
13	-	Ground & Shield*
14	I	+32 VDIRTY
15	I	GroundDIRTY*
16	I	CTSC
17	O	RTSC
18	I	RXDC
19	O	TXDC
20	-	ON/STANDBY
21	-	BIT0IN
22	-	RXDD_RS232
23	-	TXDD_RS232
24	I	+5 VDC*
25	I	+5 VDC*

* Used in COP module

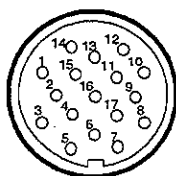
2.3.2 Front Panel Connectors

The pin assignment on the Invasive pressure connector:



Pin	Signal
1	Pressure 4 +
2	Pressure 4 -
3	Polarisation - (ground)
4	Polarisation +
5	Not connected
6	Not connected
7	Not connected
8	Not connected
9	Ground
0	Cable detection

The pin assignment on the cardiac output connector:



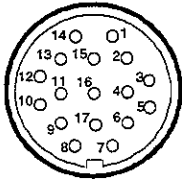
Pin	Signal
1	BAB
2	THB
3	BAC
4	Not connected
5	Shield
6	Not connected
7	THD
8	THA
9	THC
10	BAA
11	Not connected
12	Not connected
13	Not connected
14	FL
15	Not connected
16	Not connected
17	Not connected

The pin assignment on the C.O. Self Test connector:



Pin	Signal
1	CTC
2	CTA
3	CTB
4	CTD

The pin assignment on the SvO₂ connector



Pin	Signal
1	IR_CATHODE
2	CE
3	SK
4	DATA_OUT
5	CHASSIS_GND
6	SVO2_GND
7	HEATER_RTN
8	REMOTE_OUT
9	+V_OPT
10	TEMP_SENSOR
11	HEATER_HI
12	LOCAL_OUT
13	REF_RTN
14	LED_ANODE
15	RED_CATHODE
16	DATA_IN
17	-V_OPT

3 SERVICE PROCEDURES

3.1 General Service Information

Field service of the COP and COPSv modules is limited to replacing faulty mechanical parts. In all other cases, return the faulty module to Datex for repair. The COP board or the COPSv board cannot be replaced, and all calibrations can be done at the factory only.

Datex is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION: Only trained personnel with the appropriate tools and equipment shall perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

3.2 Preventive Maintenance Checks

We recommend you to perform these checks at least once a year and after any service.

1. Visual inspection

- ___: If the module is disassembled, check that all connectors are properly connected and there is no loose object inside the module before attaching the module box.

2. Functional checks

- ___: Insert the module into monitor frame.
- ___: Turn the power on by STBY-switch. COP window should appear on the display if selected for display. No error message should appear.
- ___: Pull out the module. The COP window goes blank within 15 seconds.
- ___: Reinsert the module while the power is still on. The COP measurement data appear on the window again.
- ___: Go to Service Menu, Service View, Modules, COP and check the functions of cable and probes. Check buttons (ON/OFF test).

3.3 Disassembly and Reassembly

The COP and COPSv modules are disassembled in the following way. See the exploded view of the module.

- a) Remove the two screws from the back of the module.
- b) Pull the module box slowly rearward and detach it from main body. Be careful with loose latch and spring pin for locking.

CAUTION: When reassembling the module, make sure that the cables are reconnected properly.

3.4 Adjustments and Calibrations

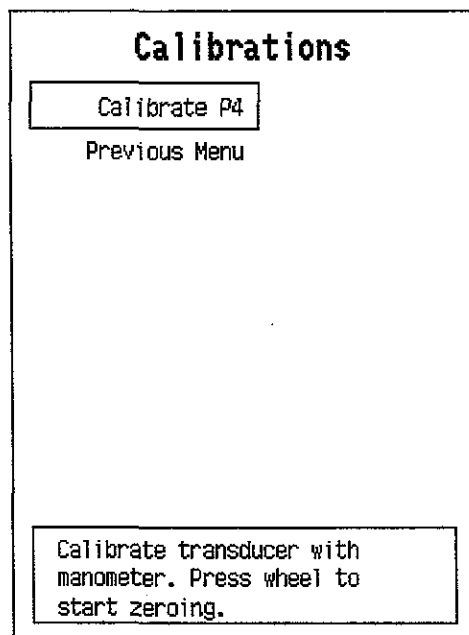
Adjustments

There are no adjustments in COP module.

Pressure calibration

Pressure calibration is recommended to be done whenever pressure transducer (probe) is replaced with another type.

1. Go to COP service page. (see chapter 5 Service Menu; Path: Monitor Setup, Install/Service (password 16-4-34), Service View (password 26-23-8), Modules)
2. Go to Calibrations.
3. Connect pressure transducer with a pressure manometer to the front panel P4 receptacle. Choose 'Calibrate P4'. Leave the transducer to room air pressure.



4. Push the ComWheel. The zeroing takes place.
5. Supply pressure of 100 mmHg to 300 mmHg to the transducer. Recommended pressure is 200 mmHg.

6. Set the pressure on the display with the ComWheel to match the pressure reading on manometer and push the ComWheel. Tolerance of ± 1 mmHg is allowed.
7. The text 'calibrated' will appear on the display.

Cardiac output calibration

The cardiac output calibration is done only at the factory.

4 TROUBLESHOOTING

Cardiac Output

TROUBLE	CAUSE	TREATMENT
NO CATHETER- message	Catheter or cable not connected.	Connect catheter (cable).
	Catheter or cable faulty.	Check by self-test. Change catheter or cable.
	Blood temp out of range.	Blood temp should be within the range.
Tinj OFF-message	No injectate temp probe.	Connect probe.
	Probe faulty.	Change probe.
	Probe wrong type.	Use Baxter compatible inj. temp probe.
	Temp out of range.	Blood temp should be within range.

SvO₂

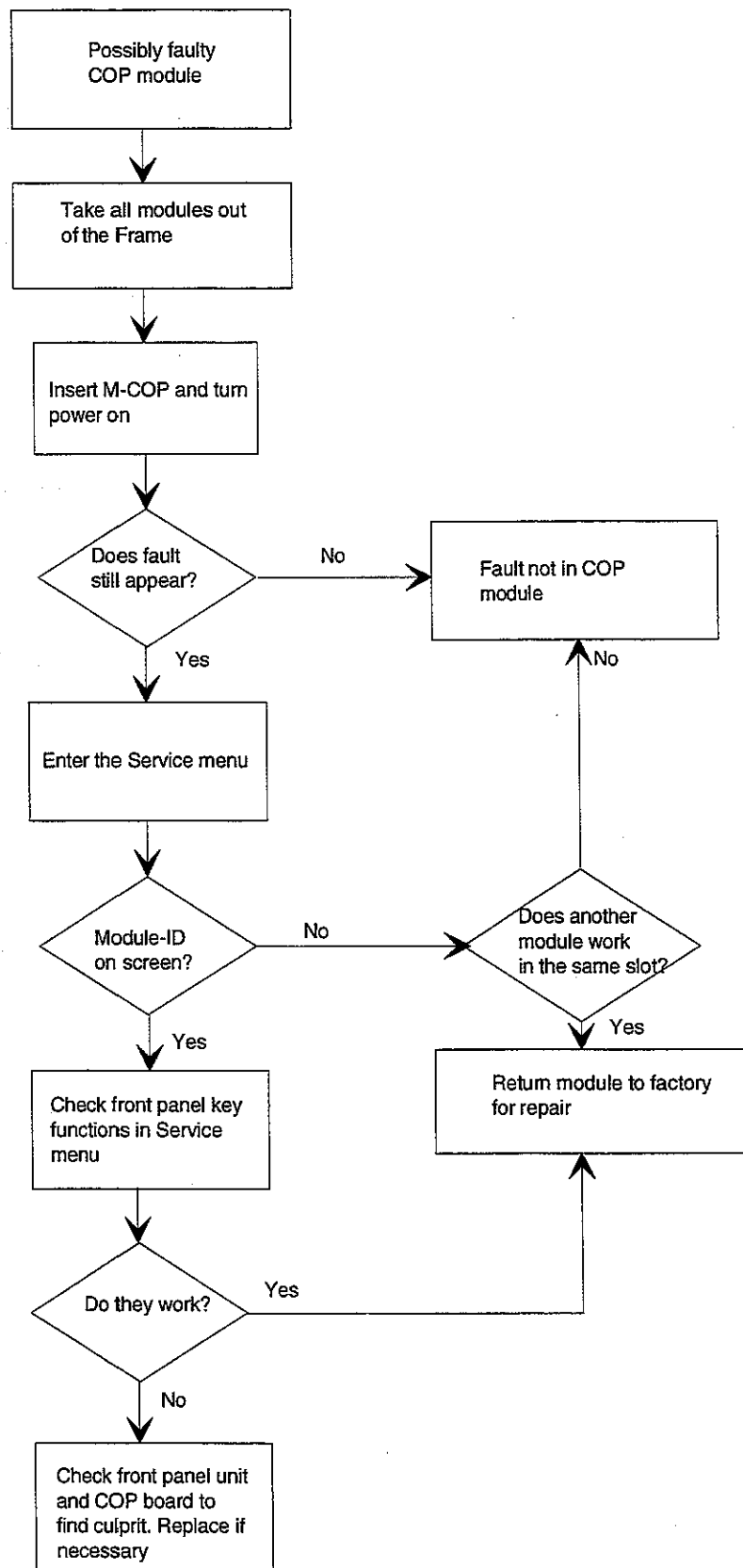
TROUBLE	CAUSE	TREATMENT
Faulty cable	Factory calibration of the optical module corrupted. Red or infrared transmit error, currents cannot be adjusted to factory defaults.	Replace optical module.
No cable	No optical module connected.	Connect optical module.
Insufficient signal	Loose catheter connection. Optical module failure. Catheter kinked or damaged.	Check connection Replace optical module. In vivo calibrate or replace catheter if needed.
Warming up	Temperature of the optical module has not yet reached the optimal value or optical module failure or COPSv module failure.	Please wait. If it takes longer than 20 minutes replace optical module or COPSv module.
Poor SvO ₂ signal	Signal pulsatility, wall contact or intensity shift signal quality level at 3.	Check number field message which problem "Check catheter position" or "Intensity shift"

Invasive BP

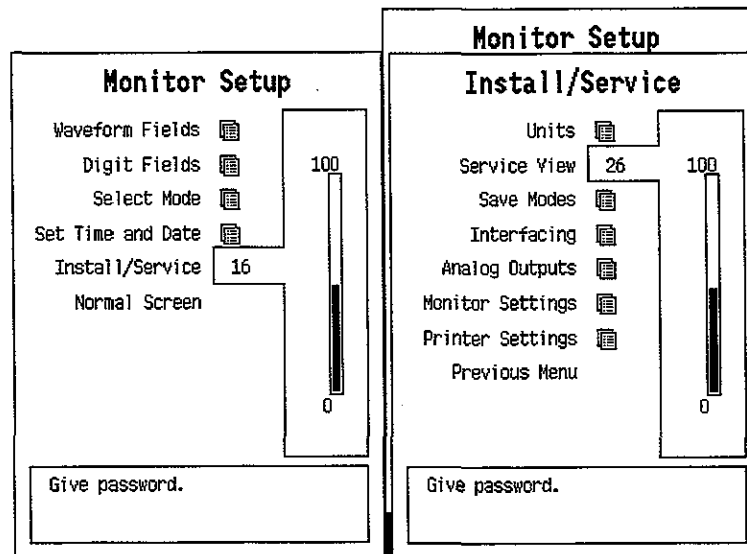
TROUBLE	CAUSE	TREATMENT
Abnormally low pressure	Transducer wrongly positioned.	Check mid-heart level and reposition transducer.
No pressure	Defective transducer. No pressure module plugged in. No waveform selected on screen.	Check transducer. Check the module. To select the desired pressure waveforms press Monitor Setup key and select modify waveforms. Check that pressure transducer is open to patient.
Not zeroed-message	Measurement on, channel not zeroed.	Zero the channel.
Zeroing failed-message	Unsuccessful zeroing of Pi (number field).	Possibly due to pulsating pressure waveform. Open the transducer to air and zero the channel. Offset is > 150 mmHg. Open the transducer to room air and zero the channel. Defective transducer. Replace it and zero the channel.
Calibration failed-message	Unsuccessful calibrating of P4 (number field).	Pulsating waveform. Turn the transducer to sphygmomanometer and try again (zeroing takes place first). Gain is beyond the limits (± 20 % of the default gain) of the module. Replace the transducer.
Out of range ≤ 40 mmHg	Measurement pressure is beyond measurement range.	Check transducer level. Zero the channel.

TROUBLE	CAUSE	TREATMENT
Out of range > 320 mmHg	Measurement pressure is beyond measurement range.	Check transducer level. Zero the channel. The patient may also have high pressure.
Zero adj. > 100 mmHg	Offset when zeroing is > 100 mmHg (but < 150 mmHg) from the absolute zero of the module (with default gain).	Check transducer. The waveform may hit the top and the numeric display not shown.
Out of range	Measured pressure is beyond the internal measurement range of the module.	The waveform hits the top and the numeric display not shown. Check transducer and its level. Zero the channel.

See also the Troubleshooting chart on the next page.



5 SERVICE MENU



To enter COP Service Menu during normal operation:

1. Press the MONITOR SETUP key. The Setup menu appears.
2. Turn ComWheel to highlight Install/Service and push.
3. Give the password by turning the ComWheel to display each password number and confirm the number by pushing the ComWheel. Password numbers are 16 - 4 - 34. The Install/Service menu appears.
4. Turn the ComWheel to highlight Service View and push.
5. Give the password by turning the ComWheel to display each password number and confirm the number by pushing the ComWheel. Password numbers are 26 - 23 - 8.
6. Turn the ComWheel to highlight Modules and push.
7. Turn the ComWheel to highlight COP module and push.

5.1 COP Service Menu

COP		Service Data			
Calibrations 					
Previous Menu					
		P4			
		Gain	20921		
		Zero	-13	C.O.	
		Cable	OFF	Catheter	Ini.
		Probe	OFF	ON	OFF
		Value	---	33.53	---
		SvO2			
		Meas. state	Normal	OM fail	OK
		Value	---	OM temp.	OK
		Gain	3	Pulse SQI	0/3
		Red int	32	Clipp. SQI	0
		IRed int	59	Int. SQI	0/3
		Loc red	371		
		Loc irec	330		
		P4			
		Button	OFF	C.O.	OFF
		Timeouts	0	RAM	OK
		Bad checksums	0	ROM	OK
		Bad c-s by mod	0	EEPROM	OK

Selectable menu items:

1. Enter P4 calibration.
2. Return to previous menu.

SERVICE DATA Detailed Description

Zero indicates offset compensation value of each parameter in A/D converter. Usually the value is within ± 1000 . **Gain** is a coefficient to compensate gain error. Typically the value is between 17000 and 25000. Calibrate if zero and/or gain value is outside the ranges.

Cable shows ON when the corresponding cable is connected to the front panel and **Probe** shows ON when the corresponding probe is connected to the cable.

Under **Value** the measured numeric values are displayed simultaneously. Pressure value is a real time value and shown in mmHg.

At the **Probe** items **Catheter** (ON/OFF) and **Inj.** (FT, BATH, or OFF) indicate connections and **Value** indicates measured temperature at 1/100th degrees of Centigrade.

Meas. state: Measurement status: No optical module (No OM) connected, initializing the optical module (Init OM), normal measurement state (Normal) and failed module (OM fail).

Value is a measured SvO₂ value.

Gain is a gain of the remote red and infrared signals (0,1,2 or 3)

Red int: Reflected red intensity

Ired int: Reflected infrared intensity

Loc red: Local red intensity

Loc ired: Local infrared intensity

OM fail: Reason why initialization OK (OK), can't read EEPROM of the optical module correctly (EEPROM), can't adjust led current to get local signal as wanted (Transmit).

OM temp: Temperature of the optical module OK (OK), temp under 43 °C (Under), temp over 47 °C (Over).

Pulse SQI: Signal quality index for pulsing (low pulse/high pulse). 0 indicates a normal signal, 1 indicates an intermediate signal, 2 indicates a poor signal, and 3 indicates an unacceptable signal.

Clipp. SQI: Signal quality index for wall artefact. 0 indicates a normal signal, 1 indicates an intermediate signal, 2 indicates a poor signal, and 3 indicates an unacceptable signal.

Int. SQI: Signal quality index for intensity shift from previous calibration or Hgb update (intensity decreased/increased) 0 indicates a normal signal, 1 indicates an intermediate signal, 2 indicates a poor signal, and 3 indicates an unacceptable signal.

The front panel key function is confirmed by pressing the key and observing OFF turns to ON at **Button**.

Timeouts is a cumulative number that indicates how many times the module has not responded to the monitor's inquiry.

Bad checksums is also a cumulative number that indicates how many times communication from the module to monitor broke down.

Bad c-s by mod is a cumulative number that indicates how many communication errors the module has detected.

The monitor starts counting these items at power up and resets to zero at power off. The nonzero values do not indicate a failure, but the continuous counting (more than 50 per second) during the normal operation indicates either serial communication failure or module not in place.

RAM indicates the state of the external RAM memory.

ROM indicates whether the checksum at the EPROM is in accordance with the one the software has calculated.

EEPROM indicates if the values stored in the permanent memory are valid.

The state is either **OK**, **Fail** or **?** (module not in place or a communication error).

6 SPARE PARTS

6.1 Spare Parts List

NOTE: Only changed part numbers are listed under later revisions. To find the desired part: check first the list of the revision that corresponds your device. If the part is not listed there, check the previous revision, etc. until you find the right number.

NOTE: Accessories are listed in the booklet AS/3 Supplies and Accessories.

Item numbers refer to the exploded view in chapter 6.2.

Cardiac Output Module, M-COP

Rev. 00

<u>Item</u>	<u>Item description</u>	<u>Order No.</u>
4	Front panel unit, M-COP (Rev. 00-02)	881191
	Membrane keypad	880101
22	C.O. Test connector, M-COP	546215
10	Front panel sticker, M-COP (Eng)	880770
10	Front panel sticker, M-COP (Fre)	881271
10	Front panel sticker, M-COP (Ger)	880978
1	Module box (single width)	886167
3	Latch	879181
2	Spring pin	879182
11	Metal frame	879184
5	Cross recess screw M3x8 black	616215
13	Cross cylinder-head screw M3x6	61721
14	Cross cylinder-head screw M3x12	628700
15	Cross cylinder-head screw M3x16	628710
16	Star washer	63611

Rev. 01

<u>Item</u>	<u>Item description</u>	<u>Order No.</u>
10	Front panel sticker, M-COP (Spa)	884387
10	Front panel sticker, M-COP (Swe)	885871
10	Front panel sticker, M-COP (Dut)	886064
10	Front panel sticker, M-COP (Ita)	886757
10	Front panel sticker, M-COP (Fin)	888871
19	EMC plate	884099
20	Protection plate	883946
21	Insulation plate for 883946	884121

Rev. 02

No new spare parts released.

A front panel unit includes all the connectors and input boards.

* = the part is recommended for stock

Cardiac Output and SvO₂ Module, M-COPSv

Rev. 00

<u>Item</u>	<u>Item description</u>	<u>Order No.</u>
5	Front panel unit, M-COPSv (Rev. 00)	888540
11	Membrane keypad	880101
12	Front panel sticker, M-COPSv (Rev. 00) (Eng)	887376
12	Front panel sticker, M-COPSv (Rev. 00) (Fre)	889551
12	Front panel sticker, M-COPSv (Rev. 00) (Ger)	889550
12	Front panel sticker, M-COPSv (Rev. 00) (Spa)	889555
12	Front panel sticker, M-COPSv (Rev. 00) (Swe)	889553
12	Front panel sticker, M-COPSv (Rev. 00) (Dut)	889552
12	Front panel sticker, M-COPSv (Rev. 00) (Ita)	889556
12	Front panel sticker, M-COPSv (Rev. 00) (Fin)	889554
9	SVO2 cable	888546
8	EMC plate	884099
1	Module box (single width)	886167
2	Latch	879181
3	Spring pin	879182
7	Metal frame	879184
4	Cross recess screw M3x8 black	616215
6	Cross cylinder-head screw M3x6	61721
10	Cross cylinder-head screw M3x12	628700

The front panel unit includes all the connectors and input boards.

* = the part is recommended for stock

6.2 Exploded View

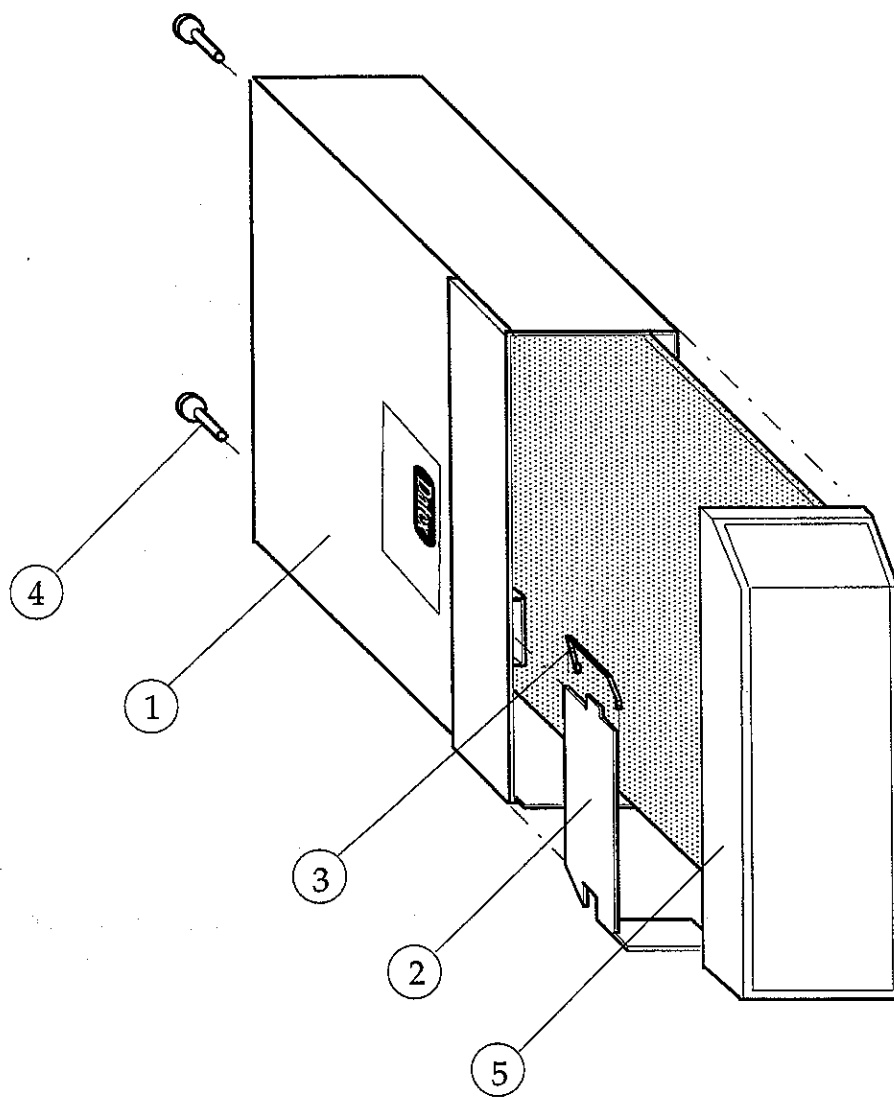


Figure 6 Exploded View of Module Box

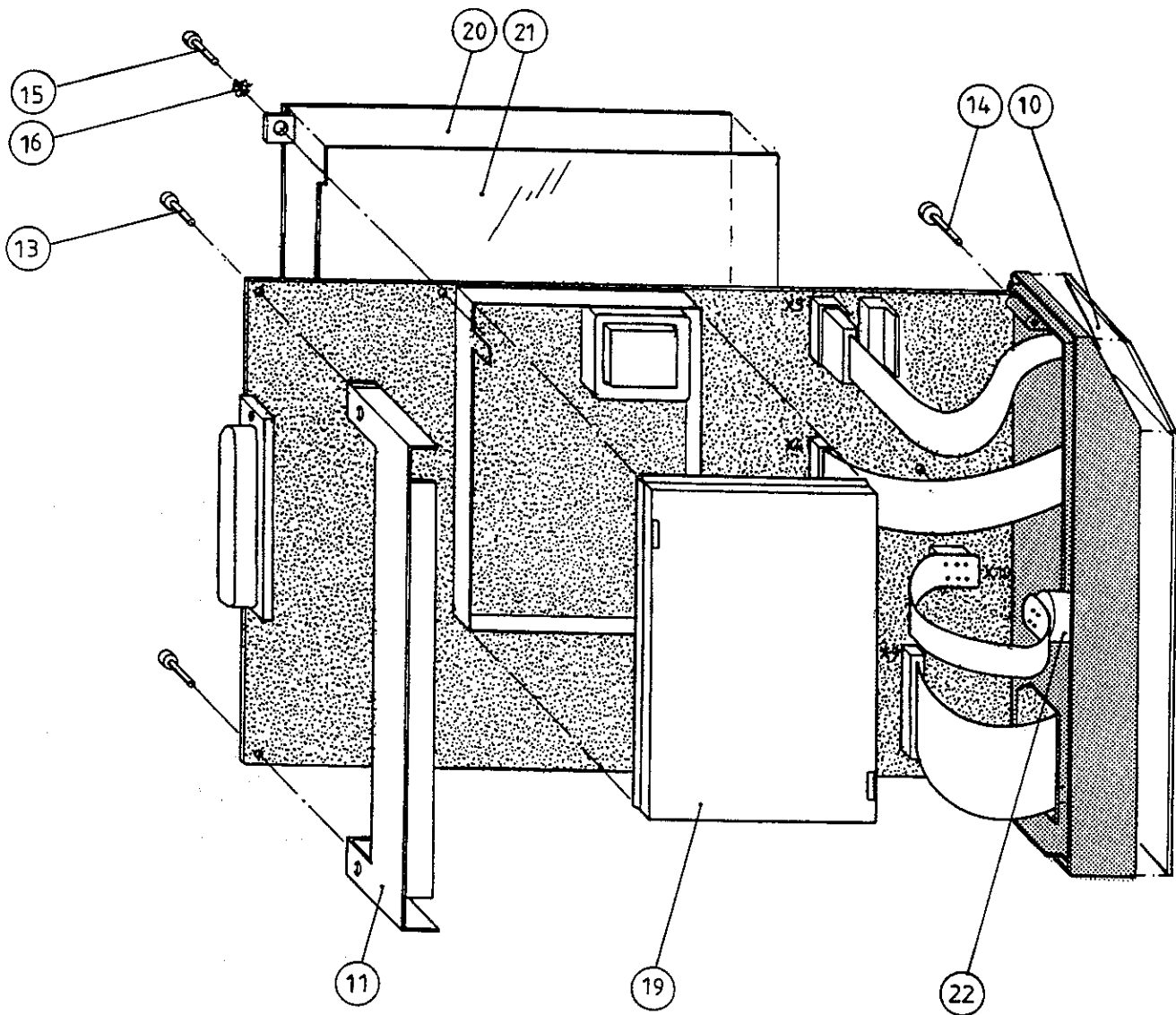


Figure 6 Exploded View of COP Module

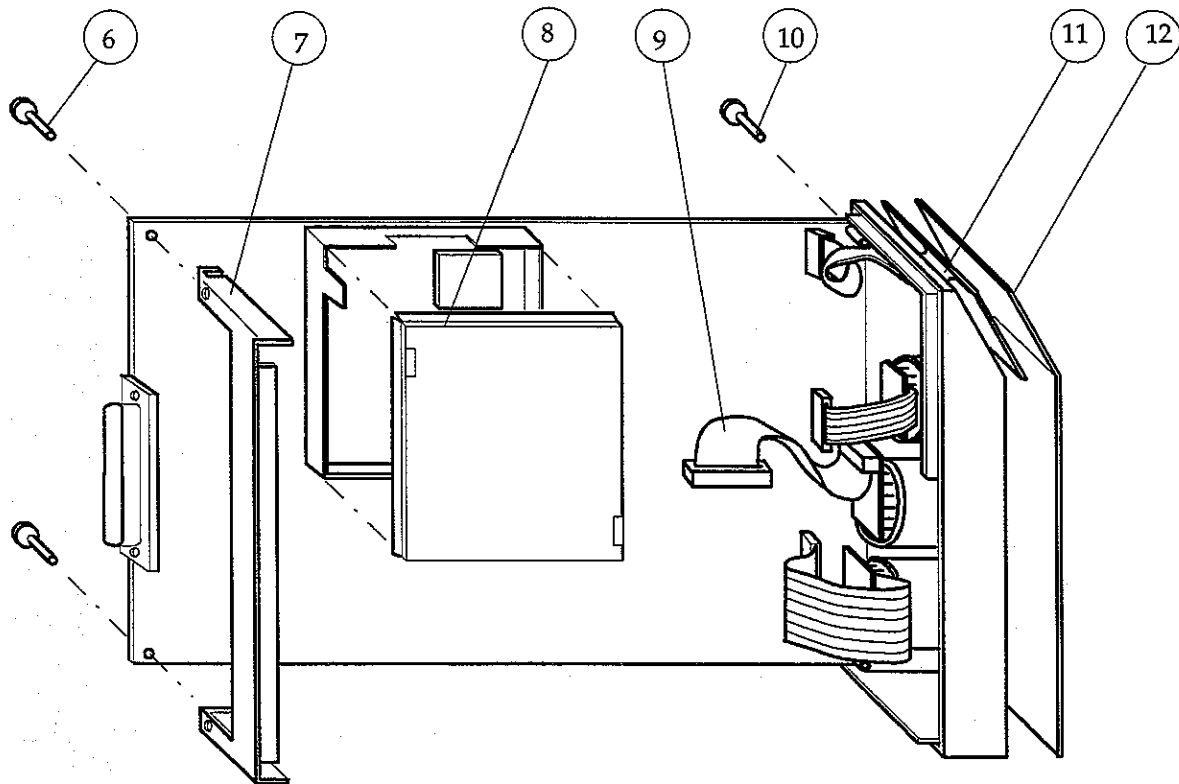


Figure 8 Exploded View of COPSv Module

7 EARLIER REVISIONS

This manual supports all earlier module revisions.

Pressure Module, M-P (Rev. 03)

Pressure Temp Module, M-PT (Rev. 00)

All specifications subject to change without notice

Document No. 885935-2

March, 1996

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INTRODUCTION

Modules M-P and M-PT are single width plug-in modules for use with the AS/3 Anaesthesia and Compact Monitors. Modules provide the third invasive pressure, and M-PT also temperature channels T3 and T4.

Additionally, the PT-module has a connector for direct ECG and pressure signal output.

NOTE: The modules M-PT and M-P cannot be used simultaneously in the same AS/3 monitor.

I SPECIFICATIONS

I.1 General Specifications

Module size W x D x H: 37 x 180 x 112 mm
1.5 x 7.1 x 4.4 in

Module weight: 0.35 kg / 0.8 lbs

Power consumption: About 3.5 W

I.2 Typical Performance

InvBP

MEASUREMENT RANGE:	-40 to 320 mmHg
Accuracy	$\pm 5\%$ or ± 2 mmHg
Zero adjustment range	± 150 mmHg
Calibration range	$\pm 20\%$
Scales	Upper limit is adjustable between 10 and 300 mmHg in steps of 10. Lower limit is 10 % of selected upper limit below zero.
Sweep speed	12.5, 25, 50 mm/s

DIGITAL DISPLAY:

Range	-40 to 320 mmHg
Resolution	± 1 mmHg

WAVEFORM DISPLAY:

Range	-30 to 300 mmHg
-------	-----------------

HEART RATE FROM ARTERIAL PRESSURE:

Measurement range	30 to 250 bpm
Resolution	1 bpm
Accuracy	± 5 bpm or ± 5 bpm, whichever is greater

Temperature

Measurement range	10 to 45 °C (50 to 113 °F)
Display resolution	0.1 °C (0.1 °F)
Temperature test	Automatic (every 10 min.)

YSI 400 probe compatible

Signal Output

ECG out	1V/mV
Pressure P3 out	1V/100 mmHg (0...300 mmHg)

I.3 Technical Specifications

InvBP

DIGITAL DISPLAY AVERAGING

Digital displays Art and P1 are averaged over 5 seconds and updated at 5 seconds intervals. All other pressures have respiration artifact rejection.

Error	$\pm 5\%$ or ± 2 mmHg
Transducer and input sensitivity	5 $\mu\text{V/V/mmHg}$, 5 VDC 20 mA max current
Input resistance	10^{10} ohms
Zero drift	< 0.1 mmHg/°C
Nonlinearity	$< 1\%$, 0 to 200 mmHg $< 2\%$, -40 to 0 and 200 to 320 mmHg
Gain drift	$< 0.05\%$ f.s./°C
Filter	0 to 4 - 22 Hz adjustable
Zero set accuracy	± 1 mmHg
Calibration resolution	± 1 mmHg
Zero time	less than 5 sec
Protection against electrical shock	Type CF defibrillation proof

NOTE: The accuracy of the measurement may be different from the specified, depending on transducer/probe used. Please check the transducer/probe specification.

Temperature

Measurement accuracy ± 0.1 °C (25.0 to 45.0 °C)
 ± 0.2 °C (10.0 to 24.9 °C)

Amplifier accuracy ± 0.1 °C (25.0 to 45.0 °C)
 ± 0.2 °C (10.0 to 24.9 °C)

Sensor accuracy ± 0.1 °C (25 to 45 °C)
 ± 0.2 °C (10.0 to 25.0)

Protection against electrical shock Type CF

NOTE: The accuracy of the measurement may be different from the specified, depending on transducer/probe used. Please check the transducer/probe specification.

Signal out

Max. delay: ECG1 15 ms
Pressure P3 25 ms
(0...300 mmHg)
Pressure offset error max. 10 mmHg

2 FUNCTIONAL DESCRIPTION

2.1 Measurement Principle

Invasive Blood Pressure

To measure invasive blood pressure, a catheter is inserted into an artery or vein. The invasive pressure setup, consisting of connecting tubing, pressure transducer, an intravenous bag of normal saline all connected together by stopcocks, is attached to the catheter. The transducer is placed level with the heart, and electrically zeroed.

The transducer is a piezo-resistive device that converts the pressure signal to a voltage. The monitor interprets the voltage signal so that pressure data and pressure waveforms can be displayed.

Temperature

The temperature is measured by a probe whose resistance varies when the temperature changes, called Negative Temperature Coefficient (NTC) resistor.

The resistance can be measured by two complementary methods:

1. Applying a constant voltage across the resistor and measuring the current that flows through it.
2. Applying a constant current to flow through the resistor and measuring the voltage that is generated across it.

In AS/3 module the two methods are combined in a form of a voltage divider. The NTC-resistor is connected in series with a normal resistor and a constant voltage is applied across them. The temperature dependent voltage can be detected at the junction of the resistors, thus producing the temperature signal from the patient. The signal is amplified by analog amplifiers and further processed by digital electronics.

2.2 Main components and block diagrams

The M-PT module consists of the following main parts:

- PT board
- Two connectors for YSI 400 series temperature probes; temperature channels T3 and T4.
- Nicolay-type connector for an invasive blood pressure sensor; invasive blood pressure channel P3.
- Key for pressure zeroing.
- DIN-type connector for two direct ECG output signals and pressure 3.

NOTE: These output-signals are non-floating

The M-P module consists of the following main parts:

- PT board
- Nicolay-type connector for an invasive blood pressure sensor; invasive blood pressure channel P3.
- Key for pressure zeroing.

Communication between the module and the AS/3 central unit is established through RS485 serial interface.

The power supply voltages to the module are generated in the power supply section of the monitor's Central Unit. All electrical connections between the module and the Central Unit are established via 25-pin D-type connector on the backside of the module.

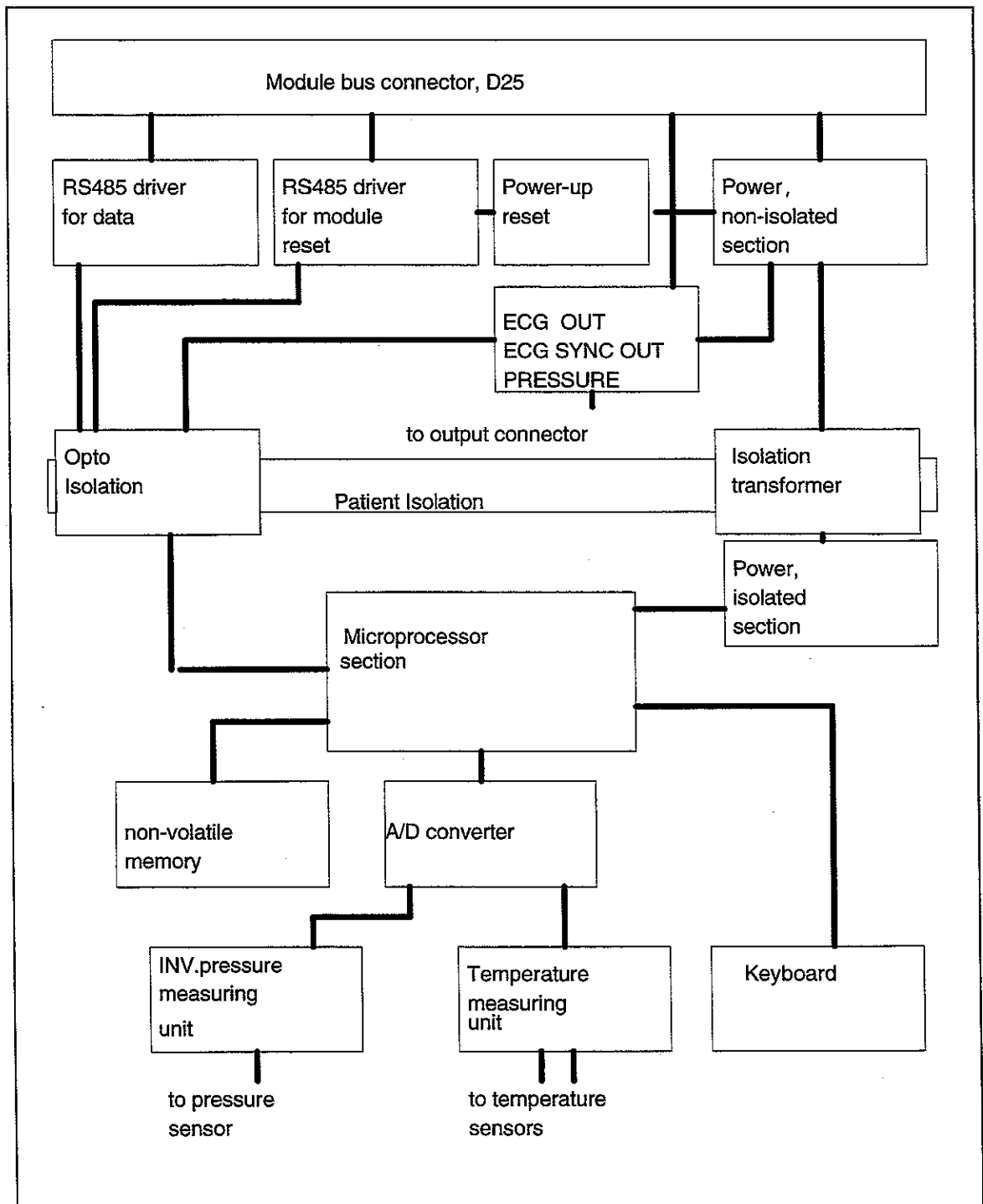


Figure 1 PT and P Module Block Diagram

ECG and pressure signal processing

The PT-module has the Signal Out connector, for output of analog ECG and pressure signals.

The analog ECG-output signals are made by detecting the pulse-width modulated (PWM) ECG signal of the AS/3 module bus. The module detects the presence of the pacemaker pulses by following the ECG module. Every time the pacer pulse has been detected, the microprocessor of the M-PT module generates a 2,5 ms pacer pulse which is added to the analog ECG signal.

The PRESSURE OUT signal is generated from the P3 invasive pressure signal of the M-PT module. The P3 signal is transmitted as a pulse width modulated (PWM) signal over the patient isolation. The analog signal is generated by low-pass filtering the PWM signal.

2.3 Connectors and Signals

2.3.1 Connectors on the board

The following connectors on the board are used, when the board is configured to M-PT or M-P:

The module bus 25-pin female D-connector (X1):

Pin No	I/O	Signal
1	I	RESET_RS485*
2	I	-15 VDC*
3	I	+15 VDIRTY*
4	I	+15 Vin*
5	I/O	NDATA_RS485*
6	I/O	DATA_RS485*
7		Ground*
8	I	NRESET_RS485*
9	I	CTSB
10	O	RTSB
11	I	RXDB
12	O	TXDB
13		Ground*
14	I	+32 VDIRTY
15	I	GroundDIRTY*
16	I	CTSC
17	O	RTSC
18	I	RXDC
19	O	TXDC
20		ON/STANDBY
21	O	PWM_ECG*
22		RXDD_RS232
23		TXDD_RS232
24	I	+5 VDCin*
25	I	+5 VDC*

* Used in the M-PT modules

X3, Keyboard connector:

Pin No	Signal	Notes
1	N/C	Not connected
2	COSWITCH	Not used
3	PSWITCH	for zeroing of P3
4	fGND	Floating GND
5	fGND	Floating GND

X4, Pressure sensor connector:

Pin No board	Pin No fr.panel	Signal	Notes
1	0	PCABEL	5V if cable not connected
2	4	PCURRENTPulse d supply to sensor	Signal from the sensor
3	3,9	P1-	
4	1	P1+	
5	2	fGND	Floating GND

When the board is configured to be M-PT, there are the following connectors connected on the board in addition to X1 and X4,.

X5, Output connector (Signal out connector on the panel):

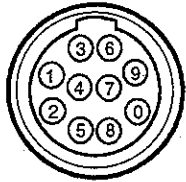
Pin No board	Pin No fr.panel	Signal	Notes
1		ECG OUT	ECG to (e.g.)IABP
2		N/C	Not connected
3	4	GND	+5VDCin GND
4	1	ECG OUT	ECG to (e.g.)defib.
5		N/C	Not connected
6	3	ECG OUT	ECG to (e.g.)IABP
7	2	P OUT	P3 to (e.g.) IABP
8	GND	GND	+5VDCin GND

X8, connector for temperature probes:

Pin No	Signal	Notes
1	T3	
2	T4	
3	fGND	Floating GND
4	CON	Low if PT
5	fGND	Floating GND
6	GND	Floating GND

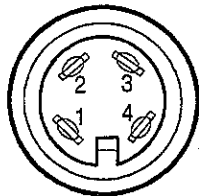
2.3.2 Front Panel Connectors

Pressure Connector



Pin No	Signal
1	Pressure 3 +
2	Pressure 3 -
3	Polarisation - (ground)
4	Polarisation +
5	Not connected
6	Not connected
7	Not connected
8	Not connected
9	Ground
10	Cable detection

Signal Out Connector



Pin No	Signal
1	ECG out, 1 V/ 1 mV
2	Pressure out, 1 V/ 100 mmHg
3	ECG out, 1 V/ 1 mV
4	Ground

NOTE: To get the ECG signal out from the Signal out connector, there must be one of the following modules in use: M-ESTPR, M-ESTR, M-ETPR, M-ESTP rev. 02 or later, M-ETP/M-EST rev. 01 or later.

3 SERVICE PROCEDURES

3.1 General Service Information

Usually field service is limited to replacing the faulty circuit boards or mechanical parts. The boards are then returned to Datex for repair.

Datex is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION: Only trained personnel with appropriate equipment shall perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

3.2 Preventive Maintenance

We recommend you to perform these checks at least once a year and after any service.

1. Visual inspection

- ___: If the module is disassembled, check that grounding wires and all connectors are properly connected and there is no loose object inside before attaching the module box.

2. Functional checks

- ___: Insert the module into frame.
- ___: Turn the power on by ON/STBY-switch. Within 15 seconds, Temp and P3 windows should appear on the display if selected for display. No error message appears.
- ___: Pull out the module. The windows go blank within 15 seconds.
- ___: Reinsert the module while the power is still on. The measurement data appear on the windows again.
- ___: Go to Service Menu (Path: Monitor Setup, Install/Service, Service View, Modules) and check the functions of cables and buttons (ON/OFF test).
- ___: Put temperature test plug into T3 and T4 and make sure that the measured values do not deviate more than $\pm 0.1^{\circ}\text{C}$. If they do, perform the temperature calibration.

3.3 Disassembly and Reassembly

Disassemble the module in the following way. See Figure for the exploded view of the module.

- a) Remove the two screws from the back of the module.
- b) Pull the module box slowly backwards and detach it from main body. Be careful with loose latch and spring pin for locking.
- c) The PT board will appear. The board is now removed by detaching two screws on the folio side of the board near the front panel and disconnecting the two ribbon cables coming from the front panel.

CAUTION: When reassembling the module, make sure that the cables are reconnected properly.

3.4 Adjustments and Calibrations

Pressure calibration

Perform pressure calibration whenever pressure transducer (probe) is replaced with another type. The pressure calibration is performed in Service Menu:

1. Go to P/PT service page (See chapter 5 Service Menu; path: Monitor Setup, Install/Service, Service View, Modules).
2. Go to Calibrations page.
3. Connect pressure transducer with a pressure manometer to the front panel P3/P4 receptacle. Choose Calibrate P3. Leave the transducer to room air pressure.

Calibrations	
Protection	OFF
Set Config	BP
Calibrate T3	
Calibrate T4	
Calibrate P3	
Previous Menu	

Calibrate temperatures with calibration plugs for 25 °C and 45 °C.
--

4. Push the ComWheel. The zeroing takes place.
5. Supply pressure of 100 mmHg to 300 mmHg to the transducer. Recommended pressure is 200 mmHg.
6. Set the pressure on the display with the ComWheel to match the pressure reading on manometer and push the ComWheel. Tolerance of ± 1 mmHg is allowed.

7. The text 'calibrated' will appear on the display.

Temperature calibration (M-PT)

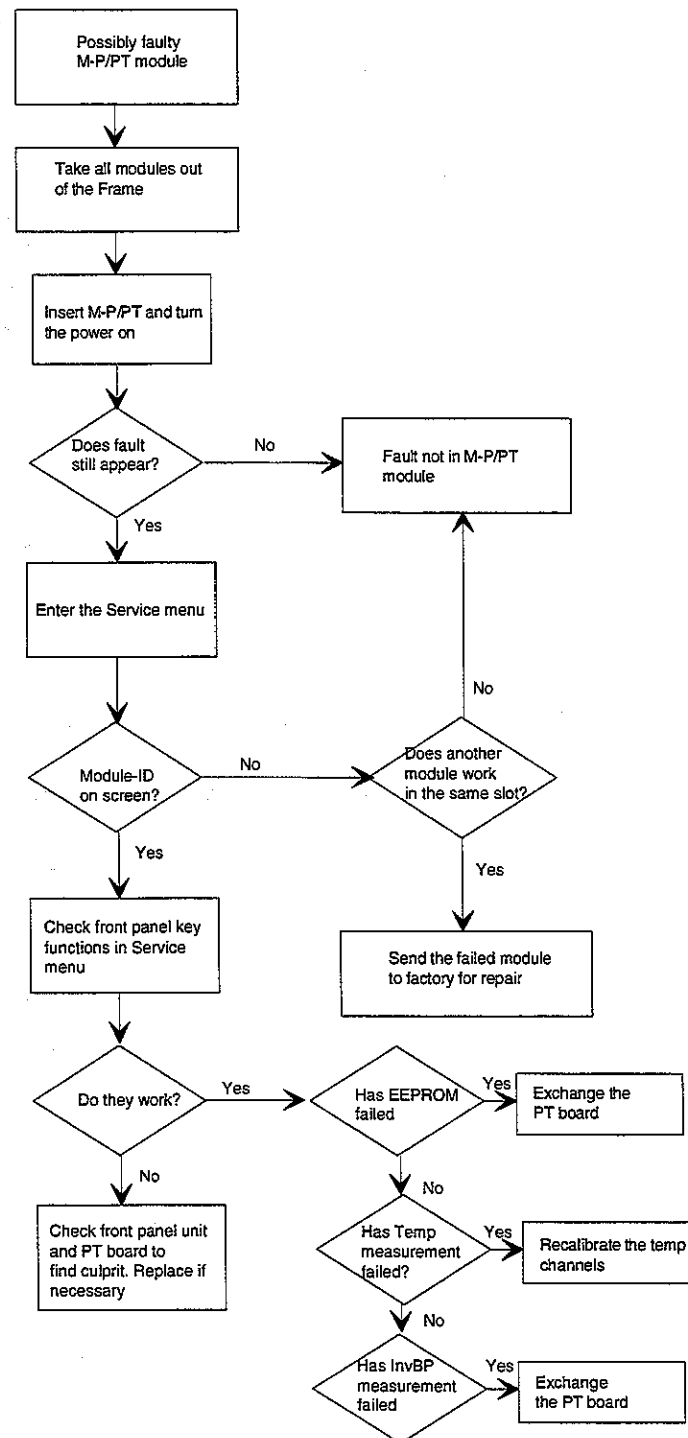
Temperature calibration is performed whenever the measured values deviate more than $\pm 0.1^{\circ}\text{C}$ when temperature test plug is inserted into T3 and T4 receptacle. The temperature calibration is performed in Service Menu:

NOTE: For the temperature calibration, separate test plugs (25°C and 45°C) are necessary. A test set of two plugs is available from Datex, order code 884515.

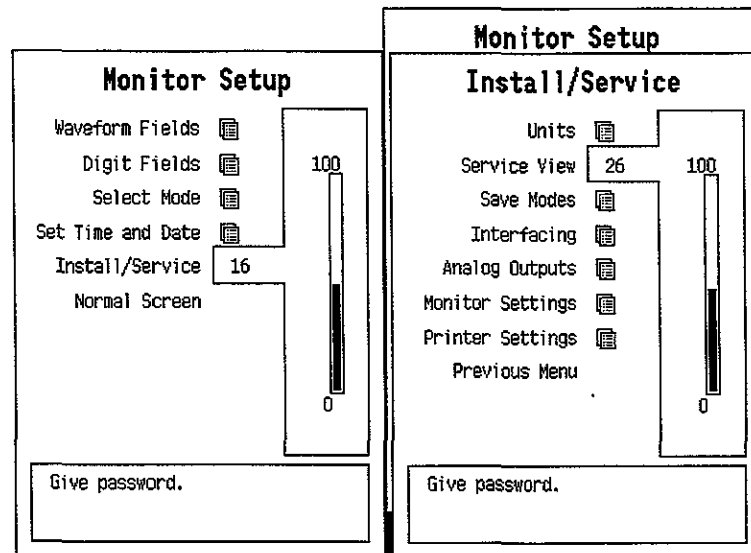
1. Go to P service page (See chapter 5 Service Menu; Path: Monitor Setup, Install/Service (password '10'), Service View (password '1'), Modules).
2. Go to Calibrations page.
3. Press in the protect button at the bottom of the module and choose OFF in Protect mode. Release the button.
4. Choose Calibrate T3/Calibrate T4.
5. Insert calibration plug (25°C) into T3/T4 connector.
6. Push the ComWheel two times.
7. Insert calibration plug (45°C) into T3/T4 connector.
8. Push the ComWheel two times.
9. Press in the protect button at the bottom of the module and choose ON in Protect mode. Release the button.

4 TROUBLESHOOTING

See also the Operator's Manual for more troubleshooting procedures.



5 SERVICE MENU



To enter Service Menu during normal operation:

1. Press the MONITOR SETUP key.
The Setup menu appears.
2. Turn ComWheel to highlight Install/Service and push.
3. Give the password by turning the ComWheel to display each password number and confirm the number by pushing the ComWheel. Password numbers are 16 - 4 - 34.
The Install/Service menu appears.
4. Turn the ComWheel to highlight Service View and push.
5. Give the password by turning the ComWheel to display each password number and confirm the number by pushing the ComWheel. Password numbers are 26 - 23 - 8.
6. Turn the ComWheel to highlight Modules and push.
7. Turn the ComWheel to highlight P module and push.

P		Service Data			
Calibrations  Record Data Previous Menu	Gain	P3	T3	T4	
		21066	13716	13763	
	Zero	1	88	89	
	Cable	ON	OFF	OFF	
	Probe	ON	OFF	OFF	
	Value	U.IU	---	---	
	Button	OFF			
	Temp error		OFF	OFF	
	Protect key	OFF			
	Protect mode	ON			
	Configuration	P1			
	Timeouts	0	RAM	OK	
	Bad checksums	0	ROM	OK	
	Bad c-s by mod	0	EEPROM	OK	

Selectable menu items:

1. Enter P3 calibration.
2. Return to previous menu.

For calibration instruction, please see chapter 3.4 Adjustments and Calibrations.

SERVICE DATA Detailed Description

Gain is a coefficient to compensate gain error. Usually the values for P1 and P2 are between 17000 and 25000 and for T1 and T2 between 13000 and 14300. **Zero** indicates offset compensation value of each parameter in A/D converter. Typically the values for P1 and P2 are within ± 1000 and for T1 and T2 between -150 and +300. Calibrate if zero and/or gain value is outside the ranges.

Cable shows ON when the corresponding cable is connected to the front panel and **Probe** shows ON when the corresponding probe is connected to the cable.

Under **Value** the measured numeric values are displayed simultaneously. Pressure value is a real time value and shown in mmHg.

The front panel key function is confirmed by pressing the key and observing OFF turns to ON at **Button**.

Timeouts is a cumulative number that indicates how many times the module has not responded to the monitor's inquiry. **Bad checksums** is also a cumulative number that indicates how many times communication from the module to monitor broke down.

Bad c-s by mod is a cumulative number that indicates how many communication errors the module has detected.

The monitor starts counting these items at power up and resets to zero at power off. The nonzero values do not indicate a failure, but the continuous counting (more than 50 per second) during the normal operation indicates either serial communication failure or module not in place.

RAM indicates the state of the external RAM memory.

ROM indicates whether the checksum in the EPROM is in accordance with the one the software has calculated.

EEPROM indicates if the values stored in the permanent memory are valid.

The state is either **OK**, **Fail** or **?** (module not in place or a communication error).

Temp error shows whether the calibration of the temperature was successful or not.

Protect key shows normally OFF but turns to ON when the button at the bottom of the module is pressed.

Protect mode is normally ON. It turns to OFF when Protect is switched to OFF for the temperature calibration in Calibration Menu.

Configuration shows the chosen module configuration: BP or PT.

6 SPARE PARTS

6.1 Spare Parts Lists

NOTE: Only changed part numbers are listed under later revisions. To find the desired part: check first the list of the revision that corresponds your device. If the part is not listed there, check the previous revision, etc. until you find the right number.

NOTE: Accessories are listed in the booklet AS/3 Supplies and Accessories.

Item numbers refer to the exploded view in chapter 6.2.

Pressure Module, M-P

Rev. 00/01

<u>Item</u>	<u>Item description</u>	<u>Order No.</u>
6	STP board, M-ESTP (Rev. 01), M-P (Rev. 00-01)	*(880339) Use 885697
4	Front panel unit, M-P	880044
	Membrane keypad	880101
10	Front panel sticker, M-P (Eng)	880139
10	Front panel sticker, M-P (Fre)	880130
10	Front panel sticker, M-P (Ger)	880488
1	Module box (single width)	886167
3	Latch	879181
2	Spring pin	879182
11	Metal frame	879184
5	Cross recess screw M3x8 black	616215
13	Cross cylinder-head screw M3x6	61721
14	Cross cylinder-head screw M3x12	628700
15	Cross cylinder-head screw M3x16	628710
16	Star washer	63611

Rev. 02

<u>Item</u>	<u>Item description</u>	<u>Order No.</u>
6	STP board, M-ESTP (Rev. 03-04), M-P (Rev. 02)	*(882627) Use 885697

Rev. 03

<u>Item</u>	<u>Item description</u>	<u>Order No.</u>
6	PT board, M-PT (Rev. 00), M-P (Rev. 03)	*885697
10	Front panel sticker, M-P (Spa)	884201
10	Front panel sticker, M-P (Swe)	885847
10	Front panel sticker, M-P (Dut)	886063
10	Front panel sticker, M-P (Ita)	886756
10	Front panel sticker, M-P (Fin)	888863
19	EMC plate	884099
20	Protection plate	883946
21	Insulation plate for 883946	884121

The front panel unit includes all the connectors and input boards.

* = the part is recommended for stock

Pressure Temp Module, M-PT

Rev. 00

<u>Item</u>	<u>Item description</u>	<u>Order No.</u>
6	PT board, M-PT (Rev. 00), M-P (Rev.03)	*885697
7	Signal out connector, M-PT	884316
8	T-input connectors	884315
9	P-input connector	884314
17	Membrane keypad	880101
18	Front panel frame, M-PT	883801
10	Front panel sticker, M-PT (Eng)	884004
10	Front panel sticker, M-PT (Ger)	885035
10	Front panel sticker, M-PT (Fre)	885033
10	Front panel sticker, M-PT (Spa)	886193
10	Front panel sticker, M-PT (Swe)	885845
10	Front panel sticker, M-PT (Dut)	886330
10	Front panel sticker, M-PT (Ita)	886758
10	Front panel sticker, M-PT (Fin)	888864
19	EMC plate	884099
20	Protection plate	883946
21	Insulation plate for 883946	884121
1	Module box (single width)	866167
3	Latch	879181
2	Spring pin	879182
11	Metal frame	879184
5	Cross recess screw M3x8 black	616215
13	Cross cylinder-head screw M3x6	61721
14	Cross cylinder-head screw M3x12	628700
15	Cross cylinder-head screw M3x16	628710
16	Star washer	63611

* = the part is recommended for stock

6.2 Exploded View

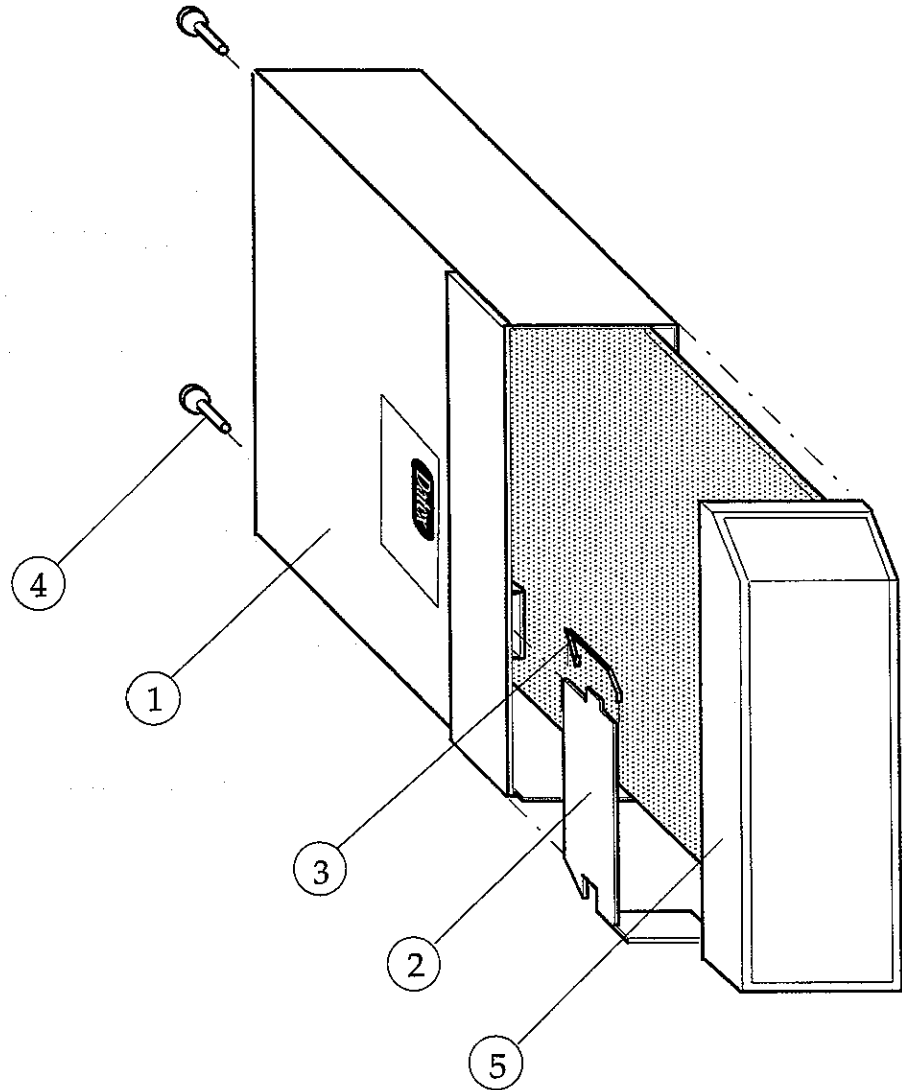


Figure 2 Exploded View of Module Box

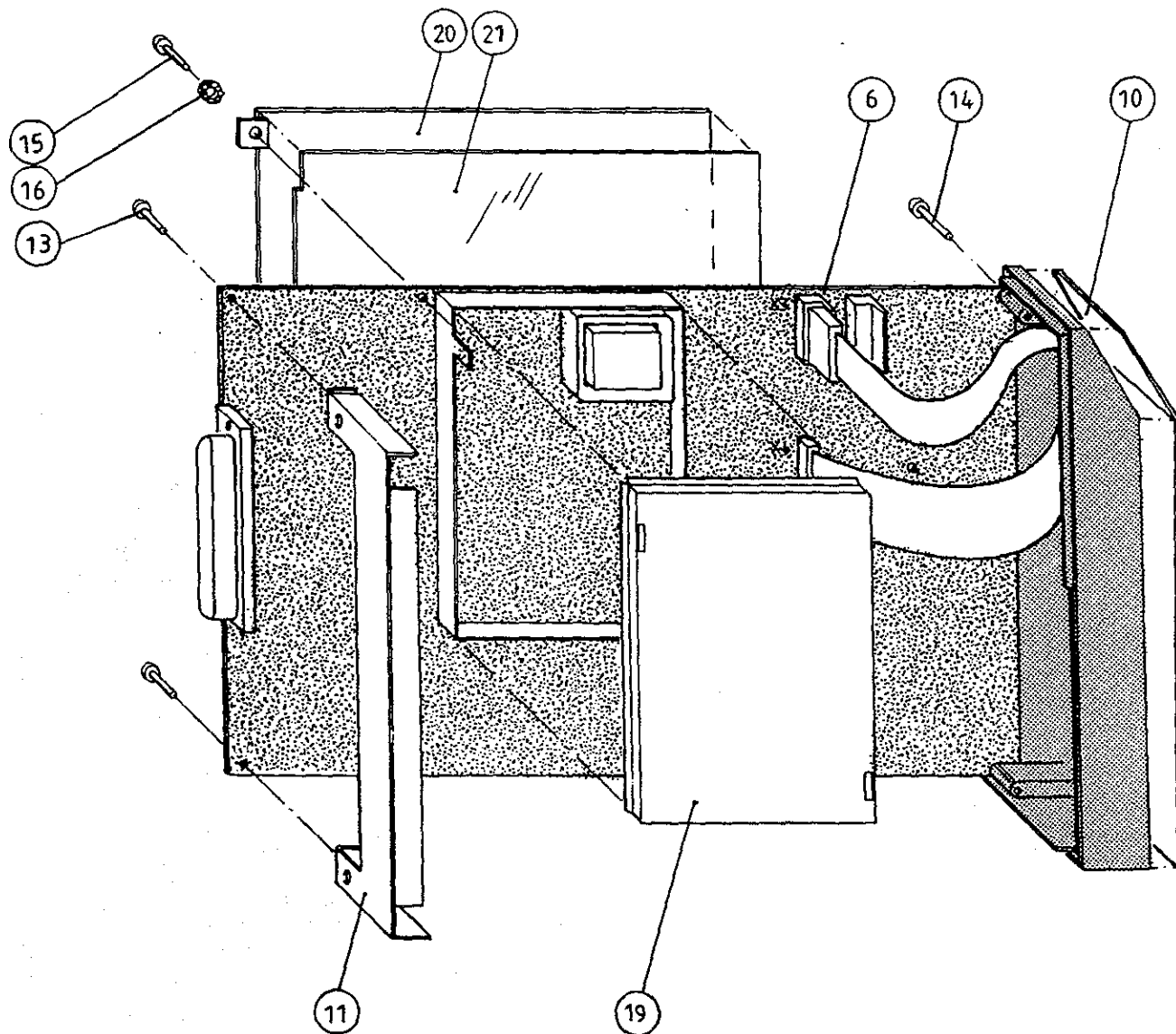


Figure 3 **Exploded View of M-P Module**

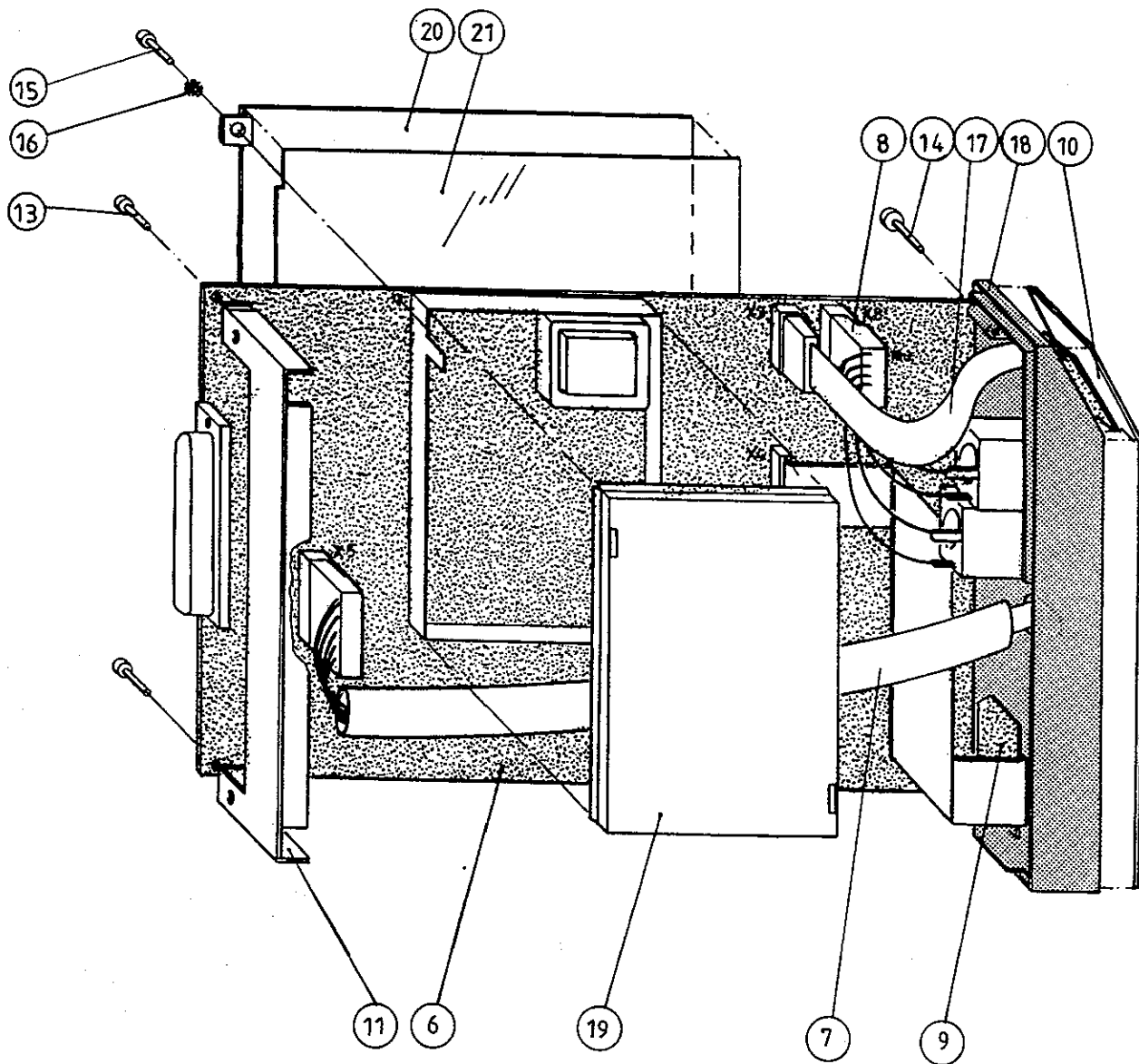


Figure 4 Exploded View of M-PT Module

7 EARLIER REVISIONS

This manual also supports M-P revision 02.

For service information on the earlier revisions, please refer to:

P Module revision 00 Service Manual p/n 880850

P Module revision 01 Service Manual p/n 882580